INDOOR AIR QUALITY REASSESSMENT

Winthrop Elementary School
162 First Street
Melrose, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Ruth Clay, Director of the Melrose Health Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) conducted a reassessment of the indoor air quality at the Winthrop Elementary School, 162 First Street, Melrose, Massachusetts. Concerns about poor indoor air quality and heat complaints prompted this request.

On February 7, 2002, a visit was made to this school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality reassessment. Kristin McRae, Health Inspector for the Melrose Board of Health, accompanied Mr. Feeney during the assessment.

The school is a two-story brick structure. The original school building was constructed around 1926 (the 1926 section). An addition was constructed in 1956 (the 1956 section). Openable energy efficient windows were installed throughout the building.

Actions on Recommendations Previously Made by MDPH

BEHA staff had previously visited the school in May 2001 and issued a report that made recommendations to improve indoor air quality in various sections of the school (MDPH, 2001). A summary of actions taken on previous recommendations is included as Appendix 1 of this report.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551.

Results

The school has a student population of 900 and a staff of approximately 40. The tests were taken during normal operations at the school. Test results appear in Tables 1-7.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were above 800 parts per million parts of air (ppm) in twenty-three out of thirty areas surveyed. While these issues require further attention, an overall comparison of carbon dioxide levels measured during the first assessment in May 2001 to the February 2002 reassessment levels (Tables 4-7), reveals improvement in areas serviced by univents. It is also worthy of mention that several areas tested actually had higher carbon dioxide levels during the February 2002 assessment in comparison to the May 2001 assessment. Please note that air monitoring was done during school hours, however students were not present in some classrooms for 10 minutes prior to testing. In addition, a number of areas had limited occupancy, which can reduce carbon dioxide levels.

The ventilation system was altered from its original design in the 1926 building. Fresh air was provided by an air handling unit (AHU) located in a large room on the ground floor that is connected to ductwork leading to air diffusers. Fresh air is drawn into the building through a vent at the rear of the building. Air is drawn through heating elements into a fan unit that distributes the air via wall mounted fresh air grilles throughout the 1926 section. The ductwork for this system is located in a crawlspace beneath the 1926 section. The exhaust system appears to depend on air pressurization to force air into classroom vents that exit the building through louvered vents located on the roof.

The function of the 1926 building ventilation system was altered by the repairs and renovations listed in the **Appendix I** of this report. The original design was intended to pressurize the building by forcing fresh air into the building through supply ductwork. This would force air from the building by pressurization. Heated air would rise and exit the building through louvers within rooftop air ducts. The installation of exhaust vent motors on the rooftop (see Picture 1) and use of the original sash window vent in the basement has reversed the air pressure relationship to *depressurize* the ductwork. The depressurization of the building can have the negative effect of drawing materials through spaces in walls, floors and ductwork.

The 1956 section classrooms have fresh air supplied by a unit ventilator (univent) system. A univent draws fresh air from a vent on the exterior of the building and air from the classroom (called return air) through a vent in the base of the unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were operating; however obstructions to airflow, such as boxes and tables blocking univents, were seen in a number of classrooms. In order for univents to provide fresh air as designed, fresh air diffusers and univent returns must be unblocked and remain free of obstructions.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please refer to Appendix 2 of this report.

Temperature readings ranged from 66^{o} F to 73^{o} F, which were below the BEHA recommended comfort guidelines in some areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control is difficult in an old building without ventilation systems functioning as designed.

The relative humidity ranged from 25 to 35 percent. All areas sampled were below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several classrooms contained a number of plants. Plant soil and drip pans can serve as sources of mold growth. A number of these plants did not have drip pans or were in outdoor type planters with no drainage. When used indoors, the lack of drip pans and drainage can lead to water pooling and mold growth on windowsills. Wooden sills can potentially be colonized by mold growth and serve as a source of mold odor.

Other Concerns

A number of efforts were made to isolate the crawlspace air from penetrating into occupied areas of the building. Several conditions continue to exist within the basement that can result in dust, dirt and other materials in the crawlspace penetrating occupied areas of the building. The floor of the crawlspace consists of a fine dirt that readily aerosolizes by drafts created by opening the access door in the basement hallway. Significant amounts of this fine dust became aerosolized as BEHA staff entered the crawlspace. In general, ventilation ductwork is not always airtight. Seams between the metal sheets of ductwork can allow air to pass into or from the duct. Since the original ductwork is damaged, rendering all seams airtight would be difficult. As originally designed, the basement fan injects outdoor air into ductwork forcing air into classrooms by creating positive pressure (Figure 2). By forcing air into the ductwork, air is forced through existing spaces in the sheet metal and into the crawlspace. The original design prevents the draw of crawlspace dust and other pollutants into ductwork. The new installation (see Figure 3) draws air from the outdoors through the original fresh air vent. This installation creates negative pressure in ducts, which tends to draw air into ducts, and in turn, may be distributed into some classrooms.

A photocopier continues to be located in an unventilated room. Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). Local exhaust ventilation is recommended in this area to help reduce excess heat and odors.

In an effort to reduce noise from sliding chairs, tennis balls are sliced open and placed on chair legs. In a previous BEHA assessment newly opened tennis balls were found to off-gas VOCs, which can be irritating to the eyes, nose and throat (MDPH, 2002). Tennis balls are made of a number of materials that are a source of respiratory irritants. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Constant wear on tennis balls can produce fibers and the off-gassing of VOCs. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix 3 (NIOSH, 1998).

Conclusions/Recommendations

The installation of the new mechanical exhaust system is one large step needed to be taken to establish a functioning ventilation system in the building. Steps taken in response to the previous BEHA assessment would serve to improve indoor air quality in the Winthrop Elementary School. Restoration of the fresh air intake fan is necessary to pressurize the supply ductwork to prevent draw of crawlspace air. Restoration of the basement fresh air supply fan to an operation speed that would only pressurize vents would serve to eliminate crawlspace air draw into the ductwork.

In order to address the conditions listed in this assessment, the following additional recommendations are made:

1. Seal the fresh air supply vent in the library with a sheet of polyethylene plastic with its entire edges secured to the walls until the fresh air supply ductwork is pressurized.
2. Examine the feasibility of restoring the fresh air supply fan to pressurize the crawlspace ductwork.
3. Render airtight all holes/seams in ductwork.
4. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
5. Consider installing local exhaust ventilation in the photocopier area.
6. Discontinue the use of tennis balls on chairs to prevent latex dust generation.

7. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up (see Appendix 4).

8. Examine the feasibility of installing exhaust ventilation for the greenhouse (see Appendix 4).

References

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Figure 2
Original Design of Mechanical Ventilation System that would Inject Outdoor Air into Ducts, Creating Positive Pressure

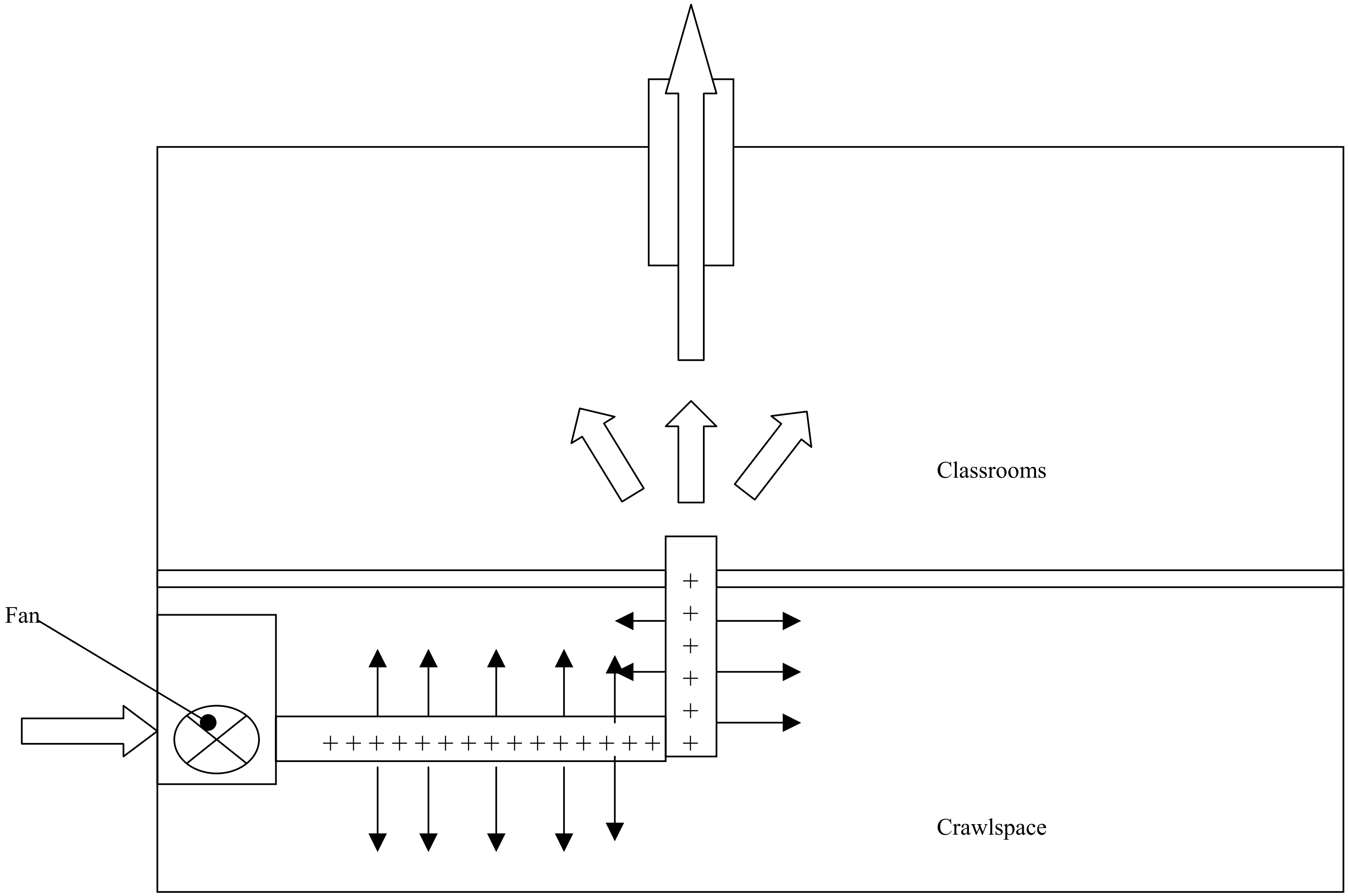
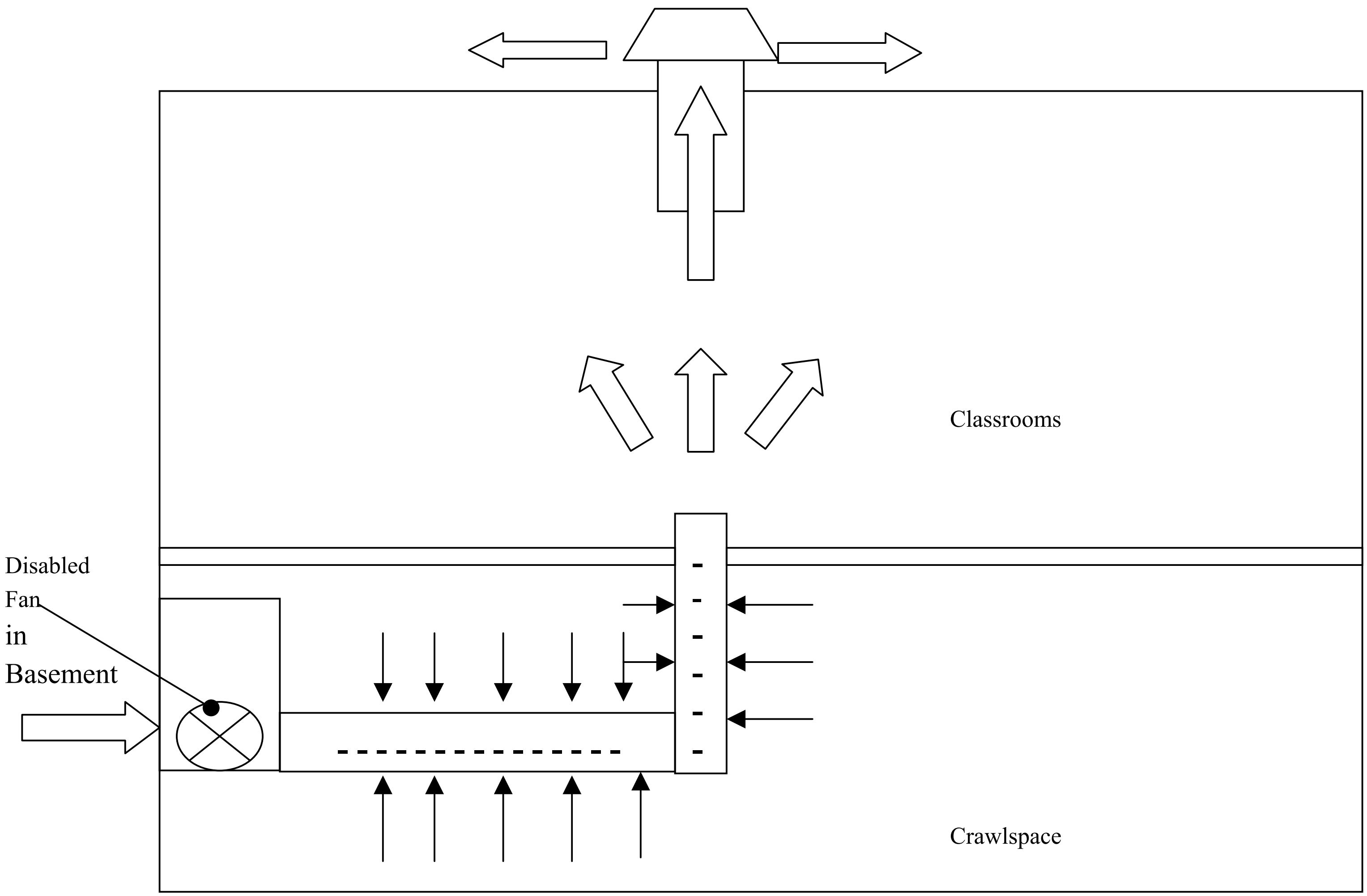


Figure 3
Redesign of Mechanical Ventilation System: Installation of Rooftop Mechanical Exhaust Fans Draw Air into Ducts Creating Negative Pressure, Which in Turn Draws Crawlspace Air into Ducts through Seams



Picture 1

A Motorized Exhaust Fan Installed on the Roof

TABLE 1

Indoor Air Test Results – Winthrop Elementary School, Melrose, MA – February 7, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	416	42	38					
Main Office	803	71	26	6	yes	yes	yes	
Foyer Office A	622	71	25	1	no	no	no	
Foyer Office D	526	66	25	0	yes	no	no	window open
Greenhouse	765	68	28	6	no	no	no	floor drain, open outside door
Classroom 32 (new wing)	1057	73	27	21	yes	yes	yes	accumulated items, door open
Classroom 31 (new wing)	1083	72	27	0	yes	yes	yes	
Classroom 28 (computer room)	800	67	37	1	yes	yes	yes	20 computers, door open
Classroom 27 (4-1)	662	67	37	1	yes	yes	yes	accumulated items, door open
Cafeteria	994	70	35	80+	yes	yes	yes	supply and exhaust off
Classroom 26 (1-1)	1117	70	29	19	yes	yes	yes	accumulated items, tennis balls

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Winthrop Elementary School, Melrose, MA – February 7, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Classroom 25 (2-2)	931	73	28	0	yes	yes	yes	door open
Classroom 24 (2-1)	843	72	28	0	yes	yes	yes	
Classroom 23 (K-1)	838	73	27	0	yes	yes	yes	door open
Teacher's Room	974	75	27	8	yes	no	no	refrigerator, coke cans
Classroom 22 (K-3)	989	73	27	0	yes	yes	yes	shelf obstructing supply
Library	739	72	26	0	yes	yes	yes	door open
Classroom 38	1178	71	29	19	yes	yes	yes	supply and exhaust off, door open
Classroom 37	784	69	26	15	yes	yes	yes	window and door open, plant
Classroom 23	1010	70	29	0	yes	yes	yes	back-draft from exhaust vent, door open
Classroom 36	1197	72	30	21	yes	yes	yes	tennis balls, door open
Classroom 35	1289	72	29	21	yes	yes	yes	accumulated items, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Winthrop Elementary School, Melrose, MA – February 7, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Classroom 34	1013	69	28	0	yes	yes	yes	accumulated items, tennis balls, chalk dust, door open
Library (11:23)	820	70	27	0	yes	yes	yes	
Speech Room	780	74	27	0	no	no	no	
Classroom 33	1139	73	27	10	yes	yes	yes	tennis balls
Bolino/Lentine Office	1209	72	26	0	yes	no	no	door open
Classroom 21 (K-2)	928	72	27	0	yes	yes	yes	shelf obstructing supply, accumulated items, door open
Classroom 1	818	69	27	0	yes	yes	yes	shelf obstructing supply, accumulated items, door open
Classroom 2	814	70	28	0	yes	yes	yes	shelf obstructing supply, accumulated items, door open
Art Room	1210	73	31	18	yes	no	no	mold odor, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Carbon Dioxide Air Monitoring Results Comparing May 4, 2001 and February 7, 2002
Winthrop Elementary School, Melrose, MA

Location	Carbon Dioxide *ppm 5/4/2001	Occupants in Room 5/4/2001	Carbon Dioxide *ppm 2/7/2002	Occupants In Room 2/7/2002	Change after Repairs (+/-) *ppm	Comments
Outside (Background)	478		416		-62	
Classroom 30	576	4	X	X	X	Room not reassessed 2/7/2002
Fitzpatrick	582	0	X	X	X	Room not reassessed 2/7/2002
Classroom 31	762	20	1083	0	+321	
Classroom 32	824	22	1057	21	+233	
Classroom 33	707	23	1139	10	+432	
Classroom 35	526	22	1289	21	+753	
Classroom 36	655	23	1197	21	+442	
Library	584	0	820 @ 11:23 AM	0	+236	

Comfort Guidelines

*** ppm = parts per million parts of air**
CT = ceiling tiles
X = comparison carbon dioxide level not measured 2/7/2002

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Carbon Dioxide Air Monitoring Results Comparing May 4, 2001 and February 7, 2002
Winthrop Elementary School, Melrose, MA

Location	Carbon Dioxide *ppm 5/4/2001	Occupants in Room 5/4/2001	Carbon Dioxide *ppm 2/7/2002	Occupants In Room 2/7/2002	Change after Repairs (+/-) *ppm	Comments
Classroom 37	477	20	784	15	+307	
Classroom 38	828	21	1178	19	+350	
Classroom 34	737	65	1013	0	+376	
Classroom 22	1197	20	989	0	-206	Operational univent 2/7/2002
Classroom 21	975	21	928	0	-47	Operational univent 2/7/2002
Teacher's Room	1017	2	974	8	-43	
Classroom 23	1090	17	828	0	-262	
Classroom 24	625	23	843	0	+218	
Classroom 25	790	24	931	0	+141	

*** ppm = parts per million parts of air**
CT = ceiling tiles
X = comparison carbon dioxide level not measured 2/7/2002

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 6

Carbon Dioxide Air Monitoring Results Comparing May 4, 2001 and February 7, 2002
Winthrop Elementary School, Melrose, MA

Location	Carbon Dioxide *ppm 5/4/2001	Occupants in Room 5/4/2001	Carbon Dioxide *ppm 2/7/2002	Occupants In Room 2/7/2002	Change after Repairs (+/-) *ppm	Comments
Classroom 26	1043	19	1117	19	+74	
Classroom 27	802	22	662	0	-142	Operational univent 2/7/2002
Classroom 28	1045	19	800	1	-245	Operational univent 2/7/2002
Cafeteria	925	1	994	80+	+69	
Classroom 1	2165	21	818	0	-1347	Operational univent 2/7/2002
Classroom 2	2477	20	814	0	-1663	Operational univent 2/7/2002
Art/Music Room	2705	21	1210	18	-1295	
AV Room	1350	0	526	0	-824	
Speech Room	1331	1	780	0	-551	

*** ppm = parts per million parts of air**
CT = ceiling tiles
X = comparison carbon dioxide level not measured 2/7/2002

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 7

Carbon Dioxide Air Monitoring Results Comparing May 4, 2001 and February 7, 2002
Winthrop Elementary School, Melrose, MA

Location	Carbon Dioxide *ppm 5/4/2001	Occupants in Room 5/4/2001	Carbon Dioxide *ppm 2/7/2002	Occupants In Room 2/7/2002	Change after Repairs (+/-) *ppm	Comments
Main Office	862	4	803	6	-59	

Comfort Guidelines

*** ppm = parts per million parts of air**
CT = ceiling tiles
X = comparison carbon dioxide level not measured 2/7/2002

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Appendix 1

The following is a status report of action(s) taken on previous BEHA recommendations (**in bold**) based on reports from building staff, documents, photographs and BEHA staff observations.

Short Term Recommendations

1. **Clean wastes from the exhaust vents on roof.**

   Action Taken: Bird waste was removed as part of the repairs to exhaust ventilation.

2. **Install wire around openings of exhaust vents to prevent bird/bat roosting.**

   Action Taken: Installation of new exhaust fans sufficiently sealed any openings.

3. **Repair windows to allow for easy opening and closing by occupants. Use open windows to provide fresh air as needed.**

   Action Taken: Several windows were randomly tested, which opened.

4. **Close all access doors in abandoned ductwork and crawlspaces.**

   Action Taken: All access doors were closed.

5. **Render airtight all holes/seams in ductwork.**

   Action Taken: Attempts were made to seal crawlspace ductwork with duct tape.

6. **Reseal all fresh air supply vents with plywood.**

   Action Taken: Repairs were made to the ventilation system to provide fresh air using these vents.

7. **Use the sash windows in air mixing rooms to introduce fresh air into the building.**

   Action Taken: The sash windows are now used to passively introduce fresh air into the ventilation system.

8. **Use open windows and hallway doors to enhance airflow during warm weather. Be sure to close windows and doors at the end of the school day. To aid in the draw of**

fresh outdoor air in warm weather, use portable fans directing air out windows on the leeward side of the building. Fans positioned in this manner will serve to increase the draw of outdoor air across a floor without interfering with the natural, internal airflow pattern of the building. To aid cross ventilation, open hallway doors in areas with inoperable transoms.

Action Taken: An evaluation of this recommendation could not be done during winter weather.

9. **Operating univents during hot weather will supplement the use of open windows. If sections of the ventilation system do not operate, the placement of fans to exhaust air from the leeward side of a building with hallway doors open may be employed.**

   Action Taken: An evaluation of this recommendation could not be done during winter weather.

10. **Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.**

    Action Taken: Plants without drip pans were noted in some classrooms.

11. **Seal the counter/backsplash seams with caulking to prevent water penetration around sinks.**

    Action Taken: Counter/backsplash seams were recaulked.

12. **Consider installing local exhaust ventilation in the photocopier area.**

    Action Taken: A photocopier continues to be located in an unventilated room.

13. **Ascertain whether material shown in Picture 14 (of the previous report, see Appendix 4), contains asbestos and encapsulate or remove in conformance with Massachusetts law.**

    Action Taken: The area noted was sealed.

14. **Consult a ventilation engineer to determine whether univents in the 1956 section can be repaired and restored to provide fresh air for classrooms. If not feasible, replacing the nonfunctioning univents should be considered.**

    Action Taken: Univents in the wing were operating during the assessment.

15. **If univents are repairable, consider increasing the filter efficiency after consultation with a ventilation engineer.**

    Action Taken: Filters could not be checked because univent case covers were blocked by obstructions.

16. **Consult a ventilation engineer to determine whether the deactivated ventilation system for the 1926 section can be repaired. Consideration should be given to installing an alternative mechanical ventilation system in this section of the school.**

    Action Taken: The ventilation system was repaired in the following manner:

    16.1. Motorized exhaust vents were installed on the roof (see Picture 1).

    16.2. Plastic, sealing the original fan system, was removed to allow for the free flow of air into ductwork.

    16.3. Ductwork in the crawlspace was sealed with duct tape.

17. **Consult a ventilation engineer to determine whether rooms now used as classrooms can be retrofitted with a mechanical ventilation system.**

    Action Taken: The repairs to the existing ventilation system were done as an alternative to retrofitting.

18. **Examine the feasibility of installing exhaust ventilation for the greenhouse.**

    Action Taken: No exhaust ventilation system could be identified in the greenhouse.